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THE CHERT GRAVELS OF EASTERN KANSAS.

By L. C. Wooster.

WHILE these chert gravels have been seen by the author of this paper in several other counties of eastern Kansas, they have been specially studied by him only in Greenwood, Lyon and Morris counties. The general features of this deposit are the same, however, wherever seen.

These chert gravels are found capping the highest bluffs, are less abundant on their slopes, and are plentiful again in the river and creek channels and beneath the bordering bottom lands. The thickness of the deposit varies from nothing up to ten or more feet, and the gravel is usually less than five inches in diameter. Its color varies from light buff, sometimes almost white, to a yellowish brown, the gravel longest exposed to the atmosphere averaging darkest in color. Many pieces contain fossils of the common Coal Measure and Lower Permian types. *Productus semireticulatus, Athyris subtilita, Fusulina cylindrica,* and various species of cup corals, crinoids and lace corals are most common.

The chert and the included fossils of the gravel are very similar to the chert and included fossils of the Wreford limestone of the "Flint Hills" in the adjacent north-and-south tier of counties to the westward. All the strata in this part of Kansas dip at a low angle to the westward, and the "Flint Hills" are slowly receding in the same direction under the eroding influence of atmospheric and aqueous agencies, and the chert gravel undoubtedly represents the resistant debris of the Wreford and Florence limestones left on the peneplain to the eastward. These Lower Permian limestones stretch across the state in a general north-and-south direction, and, since they must have been receding westward during the twelve million years that have elapsed since the close of the Paleozoic era, when eastern Kansas was lifted out of the seas for the last time, they have left a belt fifty or sixty miles wide strewn more or less thickly with their chert. In the Kansas river valley and north, the drift left by the Kansas glacier lies next above the gravel or is mixed with it.

Several interesting inferences to the student of geology may be derived from a study of these gravel deposits.

1. Were the Wreford limestone still at Emporia it would have an elevation of about five hundred feet above the Emporia series of limestones; therefore five hundred feet of rock strata has been removed by the erosive agents from central Lyon county since the "Flint Hills" were over this locality. If the average rate of denudation was that of the Mississippi basin, one foot in about five thousand years, then it has taken two million five hundred thousand years to remove these five hundred feet. The average recession westward of the "Flint Hills" during this time has been about fifteen miles, except in the river valleys, where the recession has been much greater. To have made a recession of sixty miles would have required, at this rate, ten million years. This confirms the estimated time of recession, twelve million years, as the width of the belt covered with chert gravel is more than sixty miles rather than under.

2. While Mr. Alva J. Smith was superintending the excavating necessary for a sewage disposal plant near Council Grove, Morris county, in the bottom lands bordering the Neosho river, he found several interesting relics of a previous civilization in undisturbed river silt and gravel. Resting on a stratum of limestone on a level with the bed of the river Mr. Smith found about three feet of blue clay in which were sticks of wood and the faint impression of a leaf. On this blue clay rests three feet of chert gravel. In the lower part of the gravel he found a spear head of chipped flint of crude workmanship, and an arrow point of the same material but of better shape. On the gravel rests twenty feet of river silt, constituting the main thickness of the bottom land, except at the margin, where it thins out and the gravel emerges. The latter stretches as a thin sheet up the slope of the river bluff to the top, where it thickens and caps the bluff. In the excavation in the bottom land, several rods back from the river, Mr. Smith discovered in the silt, thirteen feet below the surface, the bones of a bison, and ten feet deeper he found another arrow point of chert (flint). A tree stump on the surface of the bottom land near the excavation showed one hundred and seventy-five annual rings, and yet its roots showed scarcely any burial by silt from the river overflows.

3. While excavating for a well in the river bottoms at Eureka, Greenwood county, the workmen found just above the

chert gravel, at a depth of twenty-eight feet, the bones of a Quaternary horse, possibly *Equus major* DeKay. The bones were those of a horse larger than those of the modern animal, and, with the exception of the teeth, were badly disintegrated. One molar tooth measured three and one-fourth inches from the grinding surface to the beginning of the roots. The latter were broken at the ends and the cavities partly filled with calcite crystals. With the bones of the horse was found the cast of the shell of a river mussel of the family Unionidæ, and near the modern species *Quadrula plicata.*

4. The continued rise of the Ozark mountains of Missouri and of the Arbuckle and Wichita mountains of Oklahoma during the Paleozoic and Mesozoic eras gave the strata of Kansas a dip to the northwest and southwest, which they retained till the middle of the Cenozoic era. At this time the rise of the Rocky mountains reversed the dip of the strata in the western half of the state, greatly reduced the westward dip of the formations in the eastern half, and changed the trend of the rivers from west into the western Mediterranean to east and southeast into the rivers that make their way to the Gulf of Mexico. At the same time the rivers were rejuvenated and their work of forming a new base level was begun.

Following these orogenic movements came two or three warpings of the earth's crust in North America, which gave new phases to the problems relating to the distribution of the chert.

The geologist has proofs that early in the Glacial epoch the northern portions of our continent were elevated till they were much higher than now. Probably the increased elevation was three thousand feet at the latitude of Lake Superior and five thousand in the neighborhood of Hudson Bay, according to Dana. This high latitude elevation of the continent must have given the south-flowing rivers a much greater velocity than at present, and thus have caused them to excavate their valleys very deeply and to a great breadth. The rivers of Lyon and Greenwood counties have eroded their channels to an average depth of more than one hundred feet below the level of the highlands and to a width of from one to four miles. As these river valleys must have taken their present shape and direction since the rise of the Rocky Mountains in the Tertiary period, and have been excavated since the beginning of the

Glacial epoch, when the rivers received sufficiently high velocities through the elevation of northern lands, we have in this work of excavation, especially, a time measure of some value. At the rate of one foot in five thousand years, the work of excavating valleys one hundred feet deep would have taken five hundred thousand years, or approximately one-half of the time from the beginning of the Glacial epoch to the present. It should be remembered that only the northeastern portion of Kansas was invaded by glacier ice, that of the Kansas glacier, and the balance of the state was being denuded all the time by the atmospheric and aqueous agencies. So during all of the Glacial epoch in most of the state, and during the major portion of the time in the glaciated part, the rivers with plenty of water of high velocity deepened and broadened their valleys to near their present depth. At that time the floor of the valleys must have been covered with a layer of chert gravel from three to five feet thick, composed of the debris of the Wreford and Florence limestones, together with the flint (chert) weapons used by the aborigines of Kansas.

East of the sixty-mile-wide belt covered by the residuum of the "Flint Hills" are still other chert gravels derived from the Oread and Dennis limestones, and still farther east, mostly in Missouri, are the abundant chert gravels derived from the Mississippian limestone.

During the Champlain epoch the previous up-warping of the Glacial epoch was reversed, and the northern lands sank to a level of from three hundred to one thousand feet, according to Dana, below that possessed at present. This subsidence caused the south-flowing rivers to become sluggish and to deposit sediment rapidly. The Neosho, Cottonwood, Verdigris and Fall rivers, and probably other streams in the "Flint Hills" gravel belt, buried the chert gravels to a depth of twenty or more feet with river silt, but with increasing slowness as the bottoms increased in height.

During the Recent epoch the northern lands have recovered in part the elevation they possessed during the Glacial epoch; the rivers have increased their velocity and are again cutting into the rock strata. The rivers so rarely overflow their banks at the present time that the bottoms are scarcely holding their own in the struggle for existence. The tree stump at Council Grove showed no burial of its roots by silt, and its rings of growth showed that the tree had stood one hundred seventy-five years on this bottom.

As to the time of burial of the chipped flint (chert) weapons at Council Grove and of the horse bones and teeth at Eureka there is at present no agreement among geologists. The indications are that these relics were buried at about the close of the Glacial epoch. Some geologists fix that time at twelve thousand years, others at thirty thousand, some fifty thousand, and still others make the time one hundred thousand years ago. The author of this paper would estimate that they have been buried at least twenty-five thousand years.